Assignment 6: Gas Turbines II

1. Several F100 derivatives are being developed for multiple uses. The design throughput of the basic gas generator (i.e., turbojet) is $\dot{m}$ = 248 lbm/sec and the overall pressure ratio is 23. Calculate (by hand) the net thrust, specific thrust, TSFC, and engine efficiencies (η_p , η_{th} , η_o) for sea level, static conditions. The following component parameters apply:

Diffuser:	η_d = 1	π_d = 1	
Compressor:	η_c = 0.87	π_c = 23	
Burner:	η_b = 0.97	π_b = 1	H_f = 18,500 BTU/lbm
Turbine:	η_T = 0.92		T_{T4} = 2,460 deg R
	$\eta_{mech,T}$ = 0.98		
Nozzle:	η_N = 1	π_N = 1	

   Assume c_p = constant = 6006 ft-lb/slug/deg R and γ = constant = 1.4. **You must show all your work!!**

2. Now add an afterburner to the base engine of problem 1 and repeat your calculations. The afterburner efficiency is 90%, the afterburner pressure ratio is 0.94, and the maximum allowable temperature is 3,200 deg R. Determine the percent change in total fuel flow rate, T , and $TSFC$.

3. Now add a power turbine to the base engine of problem 1 to make it a turboshaft mated to an electric generator. Repeat your calculations. The power turbine efficiency is 89%. Assume the power turbine has the same mechanical efficiency as the turbine. If the efficiency of the electric generator is 75%, determine the maximum available electric power in kW (HINT: Consider what V_7 should be for maximum power extraction, and then assume that the power turbine expands the flow to an exit pressure of 5 psig, just enough to push the exhaust gases out of the exhaust stack).

4. Now add fan to the base engine of problem 1 to make an unmixed-flow, low-bypass ratio, two-spool turbofan. Repeat your calculations for the same overall pressure ratio of 23. The bypass ratio is β = 0.4, the fan pressure ratio is 3.8, the fan efficiency is 85%, and the fan turbine efficiency is 89%. Assume the fan turbine has the same mechanical efficiency as the turbine. Determine the percent change in T and $TSFC$.